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ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Tido Semmler, Felix Pithan, Thomas Jung

Impact of regionally increased CO2 concentrations in coupled climate simulations

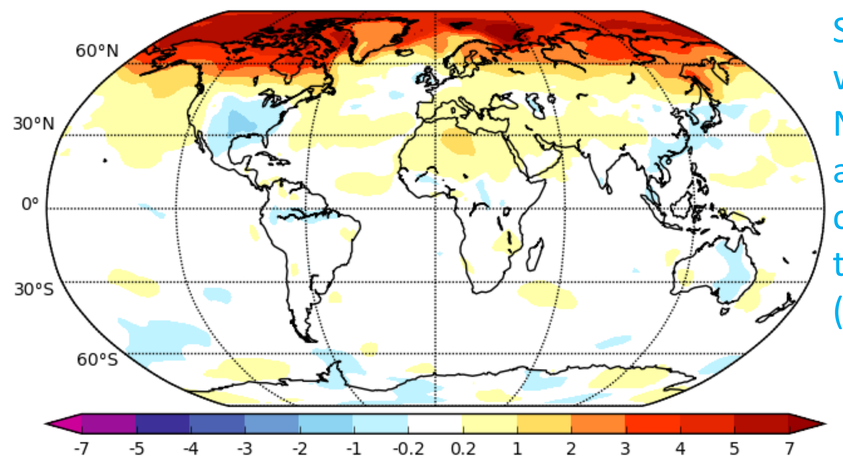
Question

- In which direction is the influence larger: from the Arctic to the mid-latitudes or vice versa?

➢ Simulation design: increased CO2 concentrations in different latitude belts for regional decomposition of response

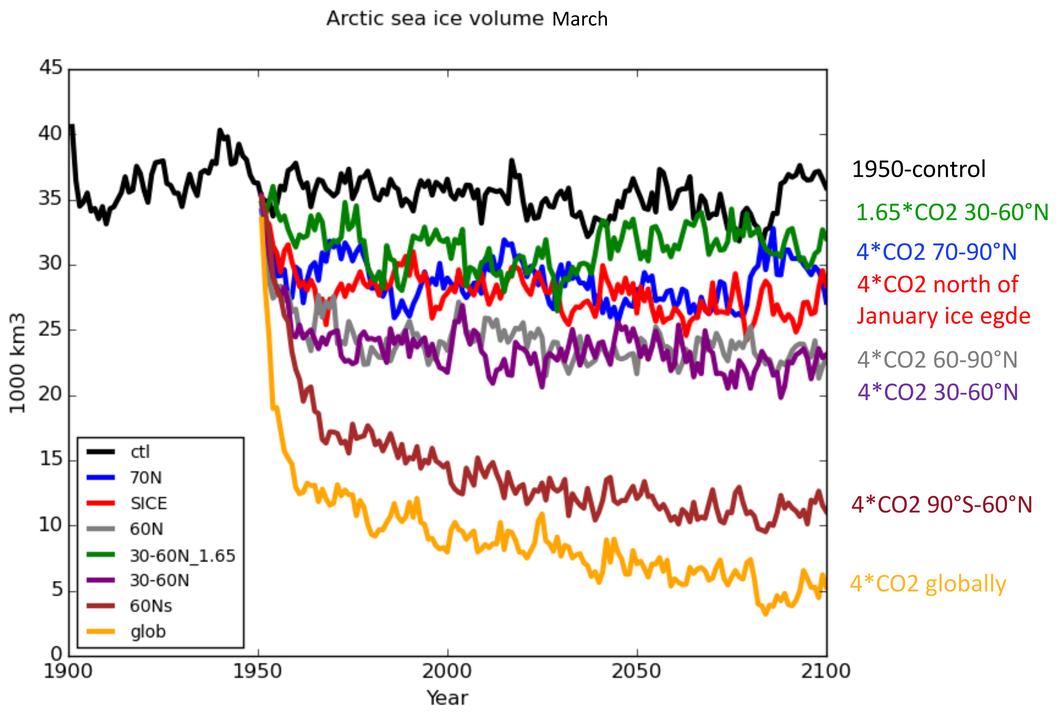
➢ Coupled model simulation protocol complementary to the standard PAMIP protocol

2 m temperature response to Arctic forcing

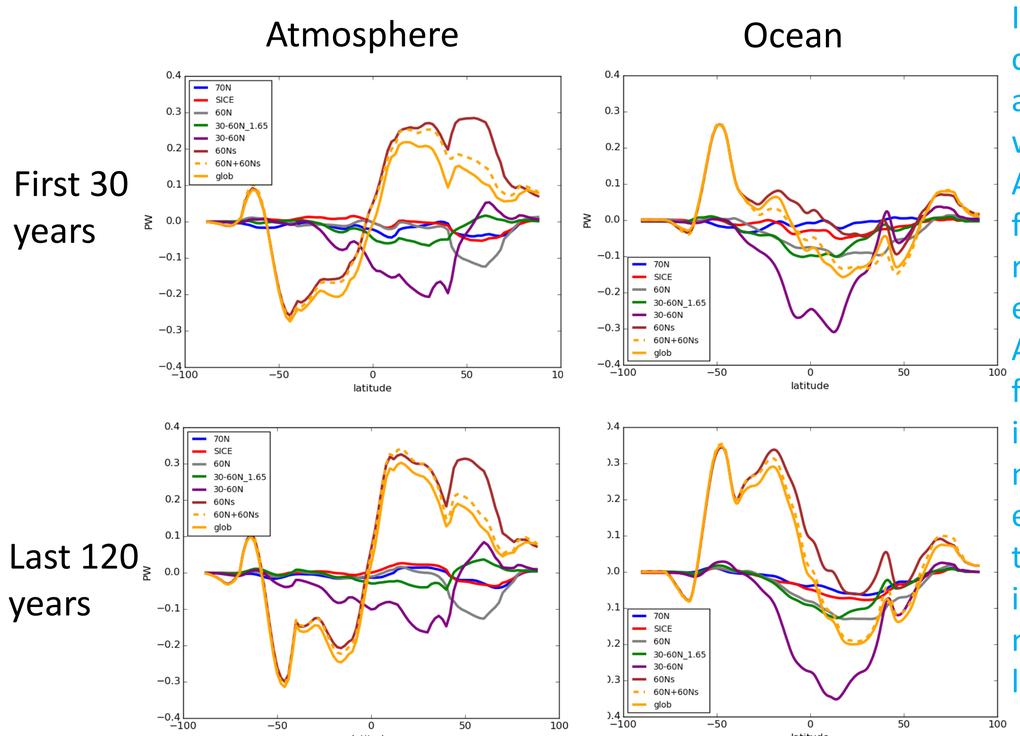


Strong Arctic warming and robust North American and Eastern Asia cooling mainly in the first 30 years (Figure).

Experiments



Northward energy transport anomaly

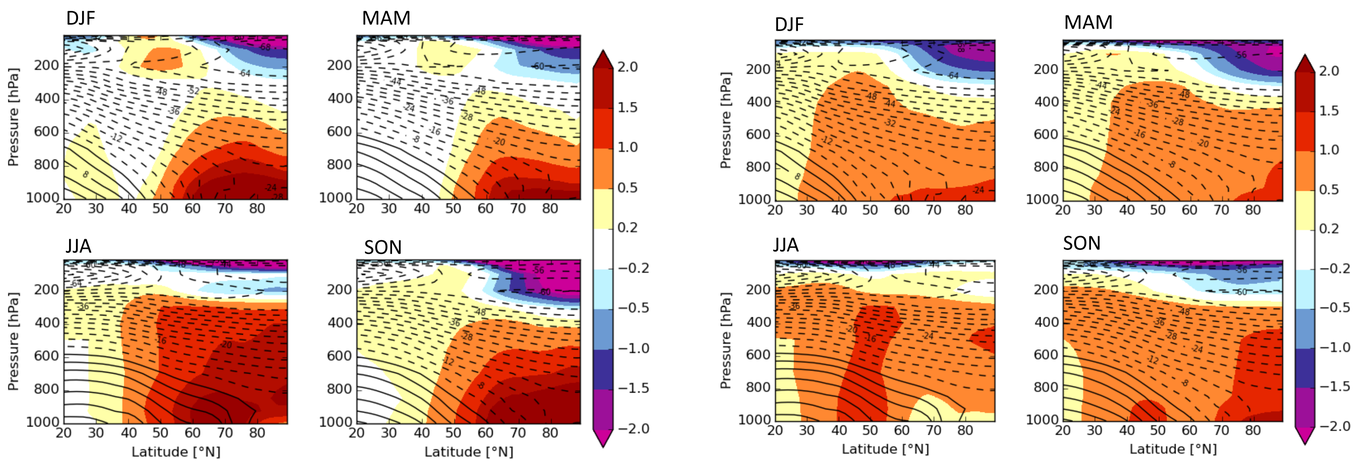


Intensification of anomalies with time; Arctic forcing reduces, extra-Arctic forcing increases northward energy transport in high northern latitudes

Vertical zonal mean temperature anomalies

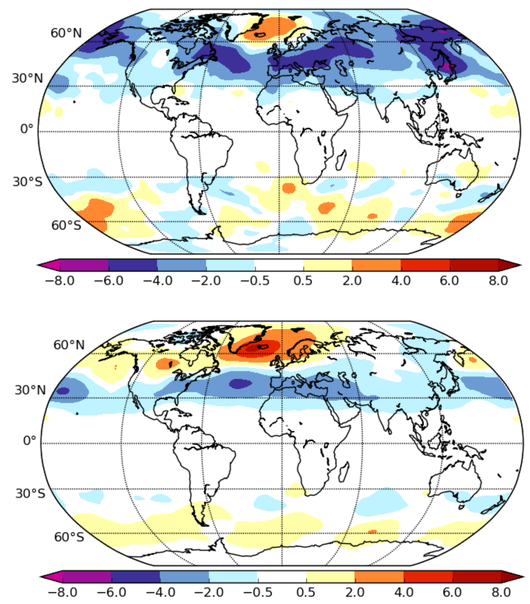
4*CO_2 60-90°N, average last 120 years

1.65*CO_2 30-60°N, average last 120 years



Warming spreads to the north but hardly to the south
Arctic stratospheric cooling in most seasons in both experiments

Synoptic activity response



4*CO_2 60-90°N, average last 120 years

4*CO_2 30-60°N, average last 120 years, scaled with forcing area

Decrease of synoptic activity with Arctic forcing except GIN seas, redistribution of synoptic activity with mid-latitude forcing

Conclusions

- Regional decomposition of CO2 forcing applied
- Arctic CO2 forcing shows limited influence on extra-Arctic regions, extra-Arctic CO2 forcing shows strong influence on Arctic including substantial sea ice melting leading to Arctic Amplification
- Meridional atmospheric and oceanic northward energy transport in high Northern latitudes is decreased in Arctic forcing experiments and increased in extra-Arctic forcing experiments
- Extra-Arctic and global forcing experiments show a fast (atmospheric) and a slow (oceanic) component in Arctic sea ice melting
- Contrast to regional CO2 forcing experiments by Stuecker et al. (2018): Stuecker et al.: local processes as major source of Arctic Amplification; our study: meridional energy transport important (amplified by local processes) – outcome dependent on experiment design? Coordinated experiments proposed!

Semmler, T., F. Pithan, and T. Jung (2020): Impact of regionally increased CO2 concentrations in coupled climate simulations. Climate Dynamics, in review.

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG
BREMERHAVEN
Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
www.awi.de

HELMHOLTZ GEMEINSCHAFT